भारतीय मानक
Indian Standard

IS 12666 : 2018

पराश्रव्य दोष मालूम करने के उपस्कर की कार्यकारिता मूल्यांकन की पद्धतियां

(पहला पुनरीक्षण)

Performance Assessment of Ultrasonic Flaw Detection Equipment

(First Revision)

ICS 77.040.20

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Non-destructive Testing Sectional Committee, MTD 21

FOREWORD

This Indian standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Non-destructive Testing Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard has been formulated for the guidance of persons involved in non-destructive ultrasonic testing and shall be useful for checking the performance of equipment and the variations in performance arising from ageing, wear and tear, etc.

To simplify methods of checking and to make them directly informative, calibration blocks including those as specified in IS 4904 : 2006 'Calibration blocks for evaluation of ultrasonic flaw detection equipment (*second revision*)' *suitable* for use both on site and in laboratory have been recommended in this standard. In certain cases, however, it has been found necessary to recommend blocks which can best be used only in a test room. Some recommendations cover only generic types of choice of dimensions; test material and surface finish being left to contracting parties who will be guided by considerations of practical relevance, such as test ranges and working sensitivity levels.

This standard was first published in 1988. While reviewing this standard in the light of experience gained during these years, the Committee felt to revise this standard. While revising this standard international practices have been duly considered along with specific Indian scenario. While revising this standard following modifications have been made:

a) Scope has been modified;
b) Reference clause has been updated; and
c) Many clauses have been modified keeping in view the International practices along with specific Indian standard.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

PERFORMANCE ASSESSMENT OF ULTRASONIC FLAW DETECTION EQUIPMENT

(First Revision)

1 SCOPE

1.1 This standard deals with methods for checking the overall performance of ultrasonic flaw detection equipment along with the probe.

1.2 This standard provides practical guidance for evaluation of some of the parameters of ultrasonic flaw detection equipment which strongly influence the integrity of flaw detection and assessment. It may be noted here that while some parameters depend only upon the probes, some others depend only upon flaw detector and the remaining parameters depend both upon the probes and flaw detector.

1.3 This standard does not cover general and environmental testing of ultrasonic flaw detection equipment.

2 REFERENCES

The following standards contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
2417 : 2003	Glossary of terms used in ultrasonic non-structive testing (*second revision*)
4904 : 2006	Calibration blocks for use in ultrasonic non-destructive Testing (*fourth revision*)

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 2417 shall apply.

4 LINEARITY OF TIME BASE OF FLAW DETECTOR

Linearity of time base depends only upon flaw detector.

4.1 Ranges

The linearity of time base shall be checked for the complete range.

4.2 Selection of Probe

For checking the linearity of time base up to 100 mm, normal beam probe of any diameter and frequency may be used. However, for ranges greater than 100 mm, both the diameter and the frequency should be as large as available. This is necessary in order to have smaller

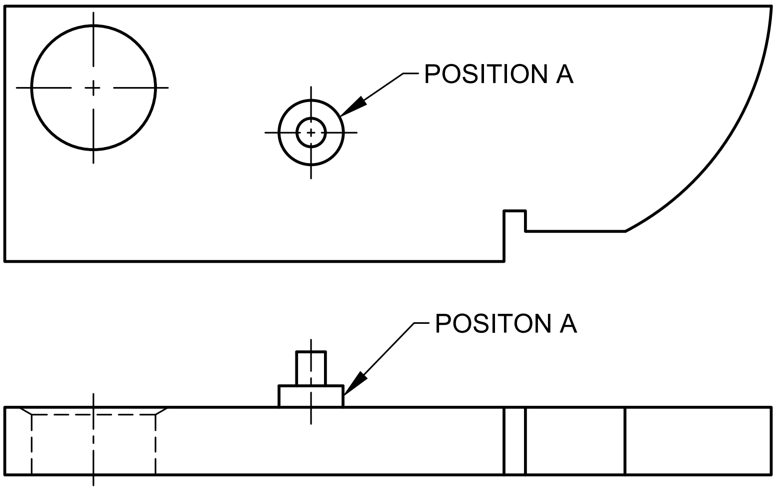


FIG. 1A PROBE POSITION FOR CHECKING LINEARITY OF TIME BASE RANGE UPTO 100 MM USING CALIBERATION BLOCK (V1)

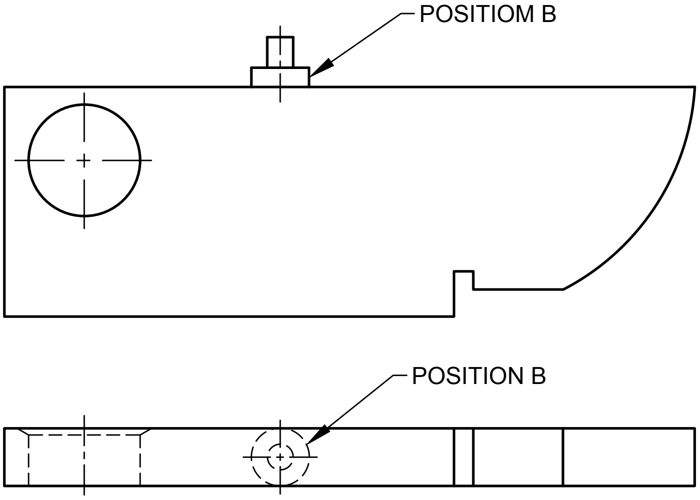


FIG. 1B PROBE POSITION FOR CHECKING LINEARITY OF TIME BASE RANGE ABOVE 100 MM USING CALIBERATION BLOCK (V2)

beam spread to avoid effects of mode transformation (for example, side wall echoes).

4.3 Probe Position

For time base ranges up to 100 mm, the probe shall be placed at position *A* and for time base ranges above 100 mm the probe shall be placed at position *B* on the calibration block (*see* Fig. 1A and 1B).

4.4 Setting of the Time Base

The time base shall be adjusted in such a way that a multiple echo pattern is displayed. Two of the bottom echo indications, separated by at least three other indications, shall coincide with the particular scale markings. The delay shall be so introduced that the first back wall echo (and not the transmission pulse or main bang) coincides with the zero marking. The last back wall echo (5th or higher) shall coincide with 100 marking. The intermediate echoes should then line up with appropriate positions on the scale.

4.5 Gain Setting

The successive bottom echoes shall be brought to nearly the same amplitude (that is, greater than half-full scale usable deflection) when measuring their positions against graticule.

4.6 Assessment of Linearity

To assess the linearity of the time base, the intervals between the leading edges of successive bottom echoes shall be measured and their deviation (say a_1, a_2, a_3,) with respect to the graticule recorded. The non-linearity (T) is calculated by the following formula using the maximum deviation (*a max*) among deviations of the stand-up points for each echo:

$$T\,(\,percent\,) = \frac{a_{\max}}{b} \times 100$$

where,

b = number of small divisions on the time base.

The result may be presented graphically by plotting the expected position of echoes on x-axis and the positions of the echoes as observed on the screen on y-axis. (*see* Fig. 2).

Non-linearity of more than ±2 percent is usually not acceptable.

5 LINEARITY OF AMPLIFICATION OF FLAW DETECTOR

5.1 General

Linearity of amplification depends upon the frequency of receiving probe used, setting up of pulse power, gain control and time base range of the flaw detector. It is desirable that the deviation from linearity of amplification be checked for all the frequency ranges and at all the settings of pulse power, gain and time base.

5.2 Probe Position

For the time base ranges of 250 mm, the probe shall be positioned at (*see* Fig 1A) on the calibration block and for a range of 500 mm shall be positioned at *B* (*see* Fig 1B). The delay shall be so introduced that the first back wall echo (and not the transmission pulse or main bang) coincides with the zero marking. The last back wall echo shall coincide with 100 marking. The last back wall echo shall be 11th in case of Fig. 1A and 6th in case of Fig. 1B.

5.3 Gain Setting

Any control for the suppression of signals below threshold level shall be first set to zero.

5.4 Assessment of Linearity

The gain shall be set to get the height of the 1st echo to be more than 90 percent of the full scale height. The height is recorded as h_1. The gain shall now be reduced by 6 dB and the height of the echo is recorded as h_2.

The gain shall further be reduced by another 6 dB and the height of the echo is recorded as h_3. Percentage deviation *Dv* is then expressed as follows:

$$D_v = \frac{h_1 - 2h_2}{h_1} \times 100 = \frac{h_2 - 2h_3}{h_2} \times 100$$

The deviation is calculated for every echo (11 echoes for 250 mm range and 6 echoes for 500 mm range).

Generally, deviation of non-linearity of more than ± 5 percent is not acceptable.

6 PENETRATIVE POWER

6.1 General

Attention is drawn to the fact that this evaluation can only be used as an indication of maximum penetrative power by direct comparison of different units, that is, instruments and/or probes. However, acceptance based on the penetrating power is subject to mutual agreement between the manufacturer and the user of the ultrasonic equipment/probe system. A definite assessment cannot be obtained using simple methods due to the differences in the manufacture of the plastic insert, influence of temperature on the results obtained, reflection from sides of calibration block, etc.

6.2 Probe Position

The probe shall be placed at the Centre of plastic insert at position *C* on the calibration block given in Fig. 3 using a time base range of 500 mm.

6.3 Gain Setting

The controls shall be set to give maximum gain and maximum pulse energy. Any control for the suppression of signals below threshold level shall be first set to zero.

6.4 Assessment of Penetrative Power

Maximum penetrative power is equal to the number of multiple echoes obtained from the bottom of the plastic insert in the block.

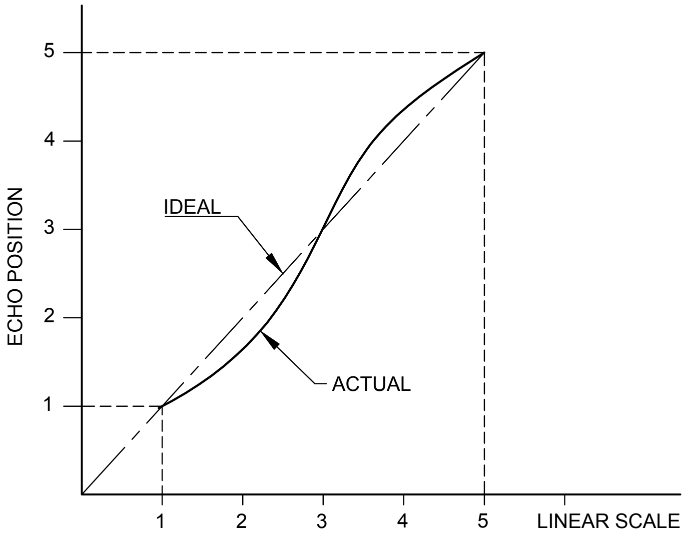


FIG. 2 EXAMPLE OF DIAGRAM SHOWING LINEARITY OF THE TIME BASE

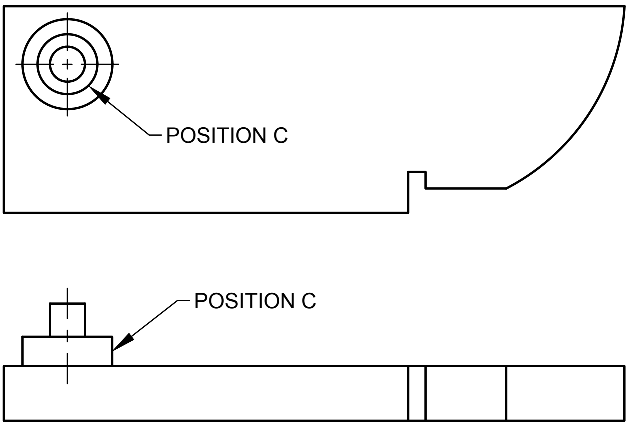


FIG. 3 PROBE POSITION FOR CHECKING RESOLUTION PENETRATIVE POWER

NOTE — An alternate method is through the use of 1.5 mm hole of the V_1 calibration block. The probe is placed as shown in Fig 4 and its position is adjusted till the echo height is maximum. With reject control and attenuation in amplifier set to zero the gain control is set to get mid-screen echo height. The gain is recorded as g_1. Next, the gain is increased till the noise between the echoes from 1.5 mm diameter hole and back wall is 20 percent. This gain is recorded as g_2.The difference between g_2 and g_1 is known as 'gain reserve', and is a measure of penetrative power or overall system gain.

Usually, a gain reserve of 30 dB may be accepted. However, this figure depends upon the flaw detector as well as on the probe. With the same probe, some flaw detectors may give higher gain reserve. Also, for critical flaw detection in highly attenuating materials, this figure may be considered low.

7 RESOLVING POWER

7.1 General

This depends upon both the probe and the flaw detector. Axial resolving power only is usually of significance. This could be expressed as near surface resolving power or far surface resolving power. However, lateral resolving power is also to be checked when two reflecting targets lying sideways at approximately the same distance from probe are to be detected.

7.2 Near Surface and Far Surface Resolving Power

The A-6 block as per IS 4904 is used for assessing near and far surface resolution. Six holes of diameter 1.5 mm each, 10 mm apart and at the depths of 1 mm, 2 mm, 3 mm, 5 mm, 10 mm and 15 mm, respectively are used for assessment of near surface and far surface resolution.

7.2.1 *Probe Position*

Probe is placed as shown in Fig. 5 for near surface resolution and at opposite surface for far surface resolution. The echoes are observed from 1.5 mm diameter holes.

7.2.2 *Assessment of Resolving Power*

The echo from the opposite surface (in the absence of any other intermediate echo) is first set to 80 percent full scale height. The probe is then moved, as shown in Fig. 5, such that the echo from 1 mm deep hole is maximized. If the echo from this hole is clearly distinguishable from the main bang, the near surface resolving power is 1 mm. If the echo from 1 mm hole is not distinguishable, then probe is successively moved to another hole until the hole echo is clearly distinguishable. The depth of the hole whose echo is distinguishable from the main bang is equal to the near surface resolving power

For far surface resolving power, probe is placed on the opposite surface of the A-6 block. The same procedure as given for near surface resolving power is followed except that the hole echo has now to be distinguishable from the echo of back wall rather the main bang.

7.3 Lateral Resolving Power

This is evaluated from the angle ø subtended by the region of maximum intensity (acoustical axis) and the line on which intensity drops down by 6 dB. It is then expressed by tan ø.

The block as shown in Fig. 4 is used. The probe is first placed to get maximum echo height from the 1.5 mm diameter hole and is then shifted sideways till the echo height drops by 6 dB. The lateral resolution is then given by tan ø or by d/R, where d is probe shift and R is the shortest distance of hole from the probe (beam path in case of angle beam probe).

8 PROBE INDEX

8.1 General

This depends only upon the probe. Probe index of an angle beam probe can be determined with the help of V1/V2 calibration block shown in Fig 1. It is advisable to position a guide strip, preferably magnetic, on one side face to ensure that the probe's movement is always parallel to the side faces. The position of the probe index should be ascertainable to within ± 0.5 mm.

8.2 Probe Position

The probe is kept on the block such as to get echo from the curved surface of the block. The probe is moved till maximum height of echo is achieved.

8.3 Gain Setting

It is recommended that rejection control be kept at zero and pulse energy at about middle position.

8.4 Assessment of Probe Index

The point of probe exactly above the centre of the curved surface of block (marked on the block) is the probe index.

NOTES

1 It is the first indispensable characteristic which should be determined before any comparisons of beam angle or beam profile are attempted. It may be significantly different than marked on the probe.

2 To meet the cases where the specified procedure or the conditions of the test call for continuous checking on site, the miniature block specified in IS 4904 is recommended. This block is 12.5 mm thick and is, therefore, prone to side wall echoes if used with too large a probe.

3 In case of squint in the probe (*see* **12**), the use of guided strip is not recommended.

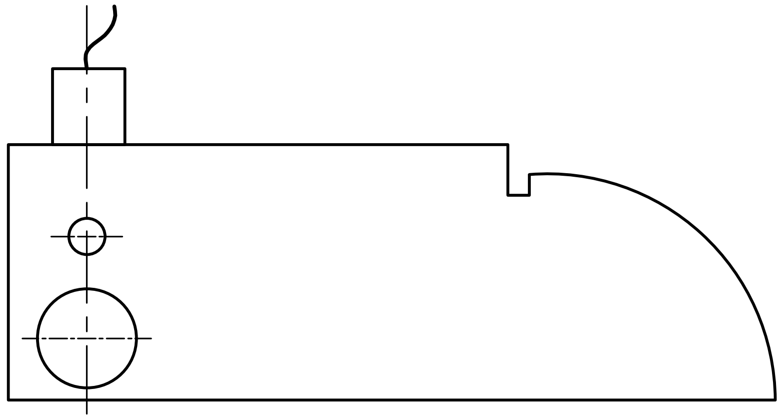
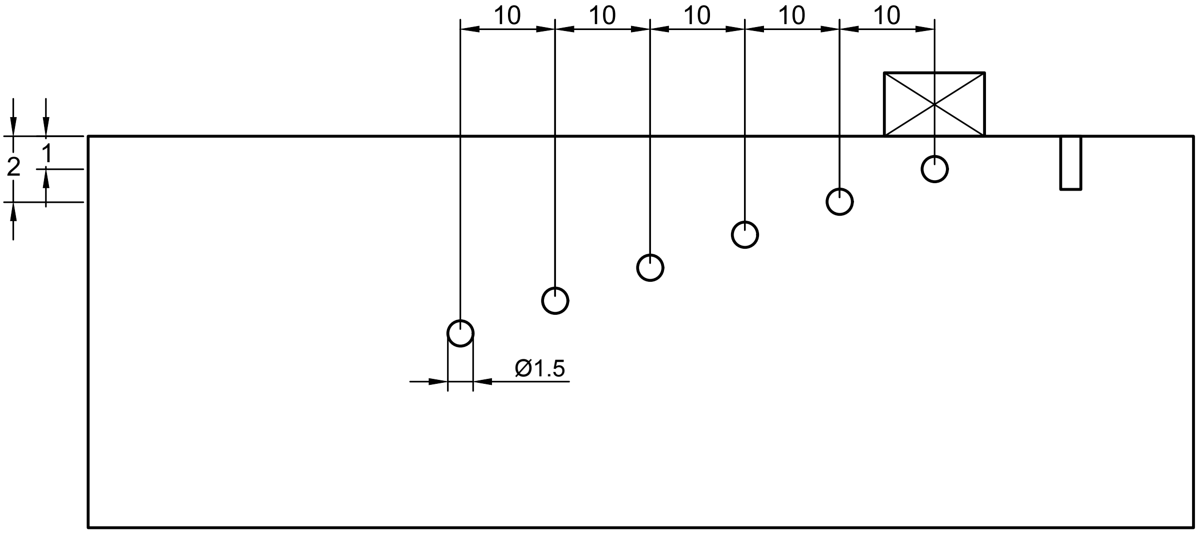


FIG. 4 TEST BLOCK SETTING FOR CHECKING OVERALL SYSTEM GAIN



All dimensions in milimeters.

FIG. 5 PROBE POSITION FOR NEAR SURFACE RESOLUTION

9 BEAM ANGLE

9.1 General

The beam angle depends only upon the probe. The calibration block (Fig. 1) can be used for the evaluation of angle at which the beam emerges out from the angle beam probe. Miniature block (*see* IS 4904) may also be used for this purpose. This block is not recommended for accurate determination of beam angle. However, it is quite suitable for detection of drift in the values of angle previously determined.

9.2 Probe Position

When block as given in Fig. 1 is used, the probe is placed such that the echo from either 1.5 mm diameter hole or from 50 mm diameter hole is of maximum height.

9.3 Gain Setting

It is recommended that rejection control be kept at zero and pulse energy at about middle position.

9.4 Assessment of Beam Angle

The angle marked on the block and lying just below the probe index is taken as the probe angle. If probe index falls between two marks, the beam angle β may be calculated as shown in Fig. 6 using the following expression (x in mm):

$$\tan\beta = \frac{x-35}{70}$$

The deviation in beam angle as specified by the manufacturer shall be within ± 2°.

NOTE — The probe should be moved from the zero degree angle position to increasing angle side. It may otherwise be misleading as a probe of 45° may show maximum height position at about 60° also.

10 BEAM PROFILE

10.1 General

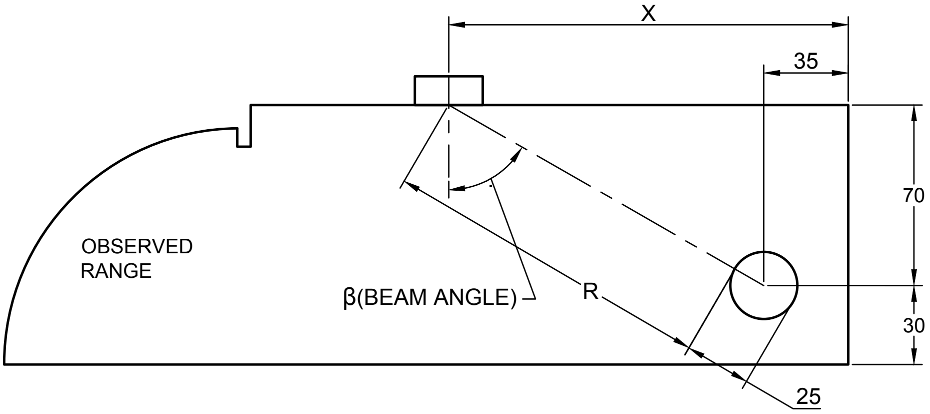
This depends only upon the probe. The method described below gives only a qualitative assessment of beam profile. For more accurate evaluation, point to point measurement of the field intensity would be required and shall not be given here. For most purposes of non-destructive testing, the method prescribed here will suffice.

10.2 Normal Beam Probe

The block shown in Fig. 7 is to be used. It has one side drilled hole such that the distance of hole's axis from four scanning surfaces is 20, 30, 60 and 90 mm, respectively. The block has reference lines marked on its surfaces just above the axis of the hole. The choice of depths of hole depends upon the need of the job. If required, another block with depth 10, 15, 25 and 40 mm may be used.

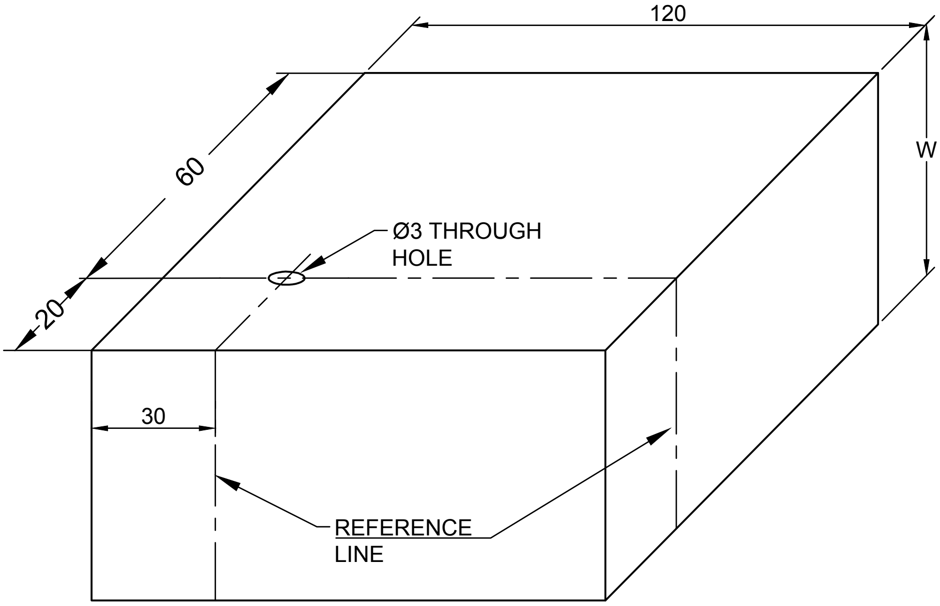
10.2.1 *Probe Position*

The probe is first marked at four reference points 90° apart (*see* Fig. 8). It is placed on the block with 1 and 3 marks of the probe on the reference line of 90 mm deep hole. Moving sideways, the echo height is maximized (position *P* in Fig. 8A). The probe is then drawn away from the target reference line until the signal has dropped to one tenth of its original height (position *P*') and the edge marked again. The shift of the probe is recorded. Care should be taken that line of probe movement is perpendicular to the reference line.



All dimensions in milimetres.

FIG. 6 CALCULATION OF BEAM ANGLE (ALTERNATIVE TO VISUAL ESTIMATION) MEASURED



All dimensions in milimetres.

FIG. 7 BEAM PROFILE BLOCK C

10.2.2 *Gain Setting*

Any control for suppression of signals below threshold level shall be set to zero.

10.2.3 *Assessment of Beam Profile*

Measurement of the probe shift gives the half-width of the beam at this level. It is plotted as distance *x* in Fig. 8B. The probe is rotated by 90° for point 2 and point 4 and the procedure repeated. The completed plot for four different depths then gives beam profile as shown in Fig. 8B.

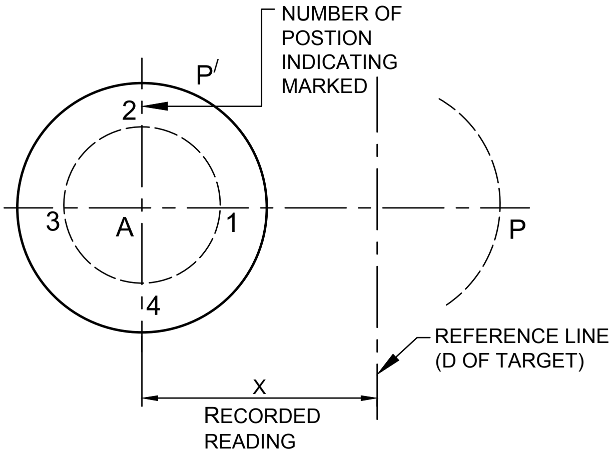
NOTE — If the maximum echo position does not coincide with the reference line on the face of the block (centre line of target) within 2 mm, the probe axis is probably not centrally aligned.

10.3 Angle Beam Probe

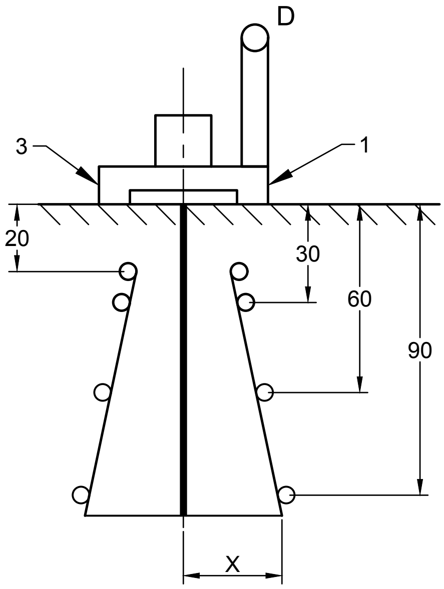
10.3.1 The calibration block, known as ‘A5 beam profile block’ as shown in Fig. 9 is used for plotting beam profile of angle beam probes. The four holes at depths 13, 19, 25 and 32 mm provide additional depths of 43, 50, 56 and 62 mm.

10.3.2 The echo from 13 mm deep hole is first maximized. At this stage, the location of the probe index on the block is recorded with reference to the front edge of the block. The echo height is also recorded.

10.3.3 The probe is now moved backwards until the echo height drops to one-tenth. The shift in probe location is recorded. This step is repeated with probe moved forward.


NUMBER OF POSTION INDICATING MARKED
P/
2
3
A
1
4
P
REFERENCE LINE (D OF TARGET)
X
RECORDED READING

8A Probe Positions



8B Beam profile

All dimensions in milimetres.

Fig. 8 Probe Positions and Beam Profiles

10.3.4 The steps mentioned at **10.3.2** and **10.3.3** are repeated for holes at other depths, too.

10.3.5 A graph, shown in Fig. 10, is plotted with shift in probe location on x-axis and depth of hole on y-axis.

11 OPERATING FREQUENCY

11.1 For accurate measurement of frequency, electronic instruments, such as, spectrum analyser, have to be used. However, for practical purposes, following method is recommended.

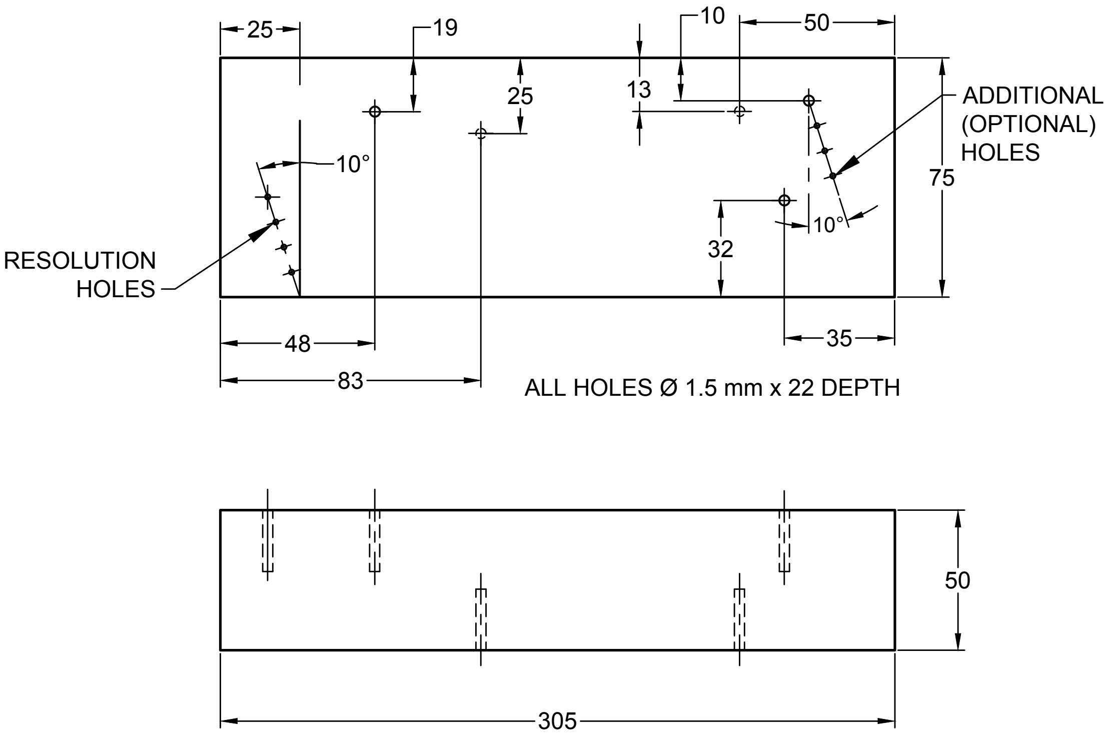
11.2 The maximum echo height from 25 mm thickness of the block is obtained. The unrectified display is used for this measurement. If the flaw detector does not provide an unrectified display, it shall be obtained by connecting an oscilloscope to the flaw detector amplifier at the point immediately before the signal is rectified. The display of unrectified pulse shall be such that the zero signal level is at mid screen and the highest amplitude cycle reaches the top or the bottom of the screen. The time scale shall be calibrated to give 5 µs full screen width.

11.3 The integral number of complete cycles which just lie within the pulse length is counted. The pulse length is measured in time as shown in Fig. 11. The frequency is then obtained by dividing the number of cycles by the time interval of pulse length.

12 BEAM ALIGNMENT (SQUINT)

12.1 Beam alignment depends only upon the probe

12.2 The angle beam probe is positioned as shown in Fig. 12 such that the echo is obtained from the longer edge of block. The probe is twisted (rotated) on the block's surface until the echo height is maximized. Any angle with respect to normal to the edge of block is the measure of squint.



All dimensions in milimetres.

FIG. 9 A5 BEAM PROFILE BLOCK FOR CHECKING BEAM PROFILE AND RESOLUTION

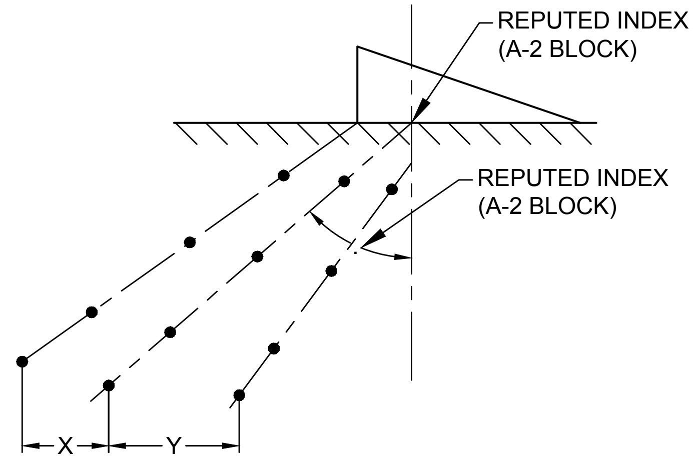


FIG. 10 SEQUENCE OF OPERATIONS FOR CHECKING BEAM PROFILES OF SHEAR WAVE PROBES

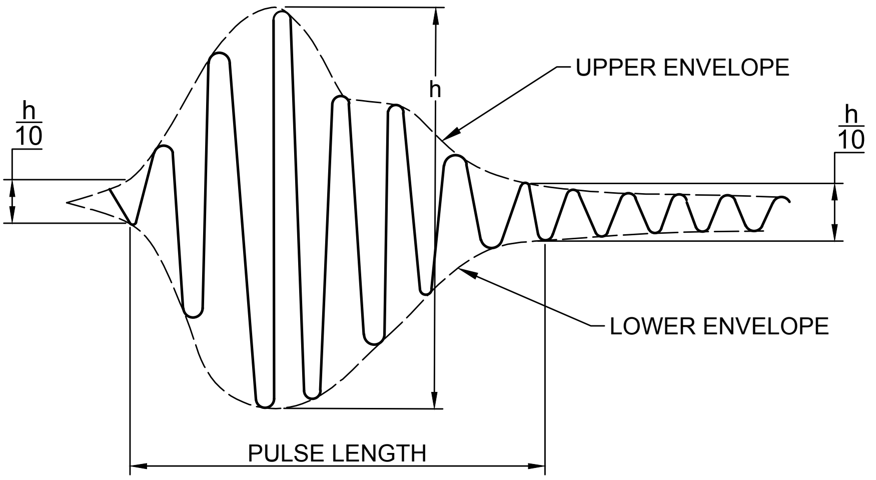
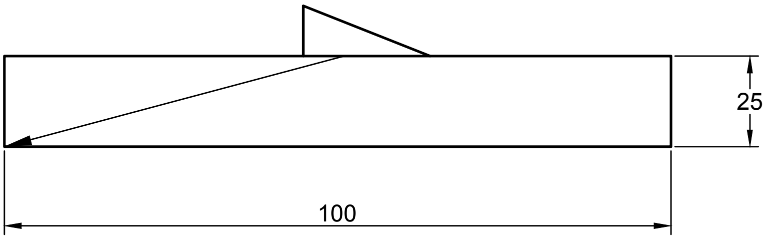
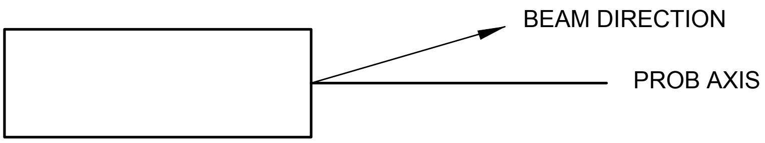


FIG. 11 DEFINITIONS OF PULSE LENGTH AND PULSE ENVELOPES



PROBE POSITION FOR SQUINT EVALUTION



All dimensions in milimetres.

FIG. 12 PROBE POSITION FOR SQUINT EVALUATION

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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of ‘BIS Catalogue’ and ‘Standards: Monthly Additions’.

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Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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